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MATERIALS AND MANUFACTURING RESEARCH AND DEVELOPMENT CAPABILITY ASSESSMENT OF THE SOUTHWEST OHIO REGION

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Interim Report

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14. ABSTRACT An assessment of the southwestern Ohio region around Dayton, OH identified organizations supporting the research and development (R&D) of materials and manufacturing techniques. The assessment was bounded by two considerations: a 25 mile radius conducive to a 30 minute drive to attend meetings and a 250 mile radius. The Cincinnati and Columbus regions were also assessed to determine if their inclusion offers significant additions to the Dayton, OH materials and manufacturing R&D cadre. In addition, an assessment of local colleges and universities offering engineering programs that support materials and manufacturing R&D was conducted using the same two radii constraints.					
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1.0 BACKGROUND

The southwestern Ohio region is well known for its heritage in flight as well as materials and manufacturing development. The Air Force Research Laboratory, Materials and Manufacturing Directorate, has been a leader in both internal and external contract research and development support for nearly 100 years. In addition to world class research and development organizations and capabilities, this region is also home to numerous colleges and universities with engineering disciplines that enable development of advanced materials and manufacturing methods.

The objective of this assessment was to identify organizations within a short driving distance within the Dayton OH region that support the following core areas of materials and manufacturing research and development:

- Non-Metals – Organic Matrix Composites, Thermal Management Materials, Nanomaterial and Nanotechnology and Biomaterials and Biotechnology
- Metals, Ceramics and NDE – Titanium Alloys, Nickel-Based Superalloys, Intermetallics, Ceramic Matrix Composites and
- Nondestructive Inspection (metals and non-metals)
- Electronics and Optical Materials – Silicon- and/or Gallium-Based Electronic and Photodetector Devices, Laser Protection
- Filters and Devices and Laser Source Materials (solid state only)

Additionally identified were local colleges and universities within the same area that offer engineering programs that were also of interest since they, not only support materials and manufacturing research and development, but also, provide graduates that can become the local organic capability to sustain this region in the future. The eight engineering fields of interest in this study are: Metallurgical, Ceramics, Materials, Manufacturing, Chemical, Industrial, Electrical and Biomaterials. The associated faculty, student populations, research funding and budgets are also of interest.

The area of interest included two regions: a short driving time radius of Dayton OH (30 mins or 25 mi) and a larger radius encompassing organization that could be reached by driving in a half of a day (250 mi). These distances were of interest to support collaboration; the 30 minute short driving time radius could support quick meetings or delivery of interesting samples between organizations. The larger, half-a-day radius would support collaboration at a more formal scale to support meetings that would require an overnight stay (or a late return).

2.0 REGIONAL ASSESSMENT APPROACH

There were three major sources used to generate the company list. The first and most valuable source came from the Dayton Area Defense Contractors Association website (DADCA). The DADCA is an organization that supports Dayton's defense industry. Each company was analyzed from its website for inclusion or exclusion from the list. Most of the companies were within a 25 mile radius of Dayton, but some companies were a little farther away.

The second source was the Thomas Register. Thomas Register has been published for over 100 years, so it is a well-known and respected source. Thomas Register also has a useful feature in which to search within a certain radius. This helped to broaden the search to include companies in the Cincinnati and Columbus areas.

Various industrial base assessments and reports were also used to identify companies. For instance, the 2010 Air Force Annual Industrial Base Assessment was used to find larger companies within the 250 mile radius. Most are larger companies such as Boeing, Lockheed Martin, and Pratt & Whitney but there are some less known companies such as Laird Technologies, Cytec, or Texstars.

Internet searches and "US News and World Report" college ranking were used to identify universities that met the distance and engineering field criteria. The 250 mile radius of Dayton covers all or most of Ohio, Indiana, Kentucky and West Virginia, and the southern half of Michigan, eastern Illinois, northern Tennessee, western Virginia and western Pennsylvania. Only universities in this region that offer at least a Bachelor's degree were considered; therefore, community colleges were not considered for this report. Additionally, many universities have satellite campuses located throughout the state. Only the main campus' information was used for this report.

This report concentrates on the eight specific engineering programs; however most universities offer other engineering degrees such as Aerospace, Bioengineering, Civil, Computer, Mechanical, and Nuclear that might be useful.

There are a few resources available for university and engineering program ranking. For consistency, IBIC chose to use only one, US News and World Report, for the rankings.

There are a large amount of companies and universities located in the 250 mile radius zone. Emphasis was placed on finding all companies and universities within 25 miles of Dayton. As the search area was expanded to 250 miles, generally only the larger, more prominent companies in the aerospace industry were researched for the report.

3.0 FINDINGS

Using the mileage and materials and manufacturing criteria, 69 companies were identified within the defined area that manufactures or performs research and development in at least one area of the three materials disciplines of interest. Thirty companies are located within 25 miles of Dayton, OH and an additional 15 companies are located in the Cincinnati or Columbus area. The other 21 companies are located within 250 miles of Dayton. This report is table driven with the following tables containing all (if available) the requested information. It should be noted that five companies (Alcoa Howmet, PCC, Laird, GE Aviation, and Applied Composites Engineering) are listed twice because they have two locations and one company, ATI-Allegheny Ludlum, is listed three times because they have three locations within the specified mileage criteria.

Using the mileage and academic criteria, 38 universities were identified that offer at least one of the eight engineering specialties. Five universities (Cedarville, Central State, University of Dayton, Wilberforce and Wright State) are located within 25 miles of Dayton. The other 33 universities are located within the 250 mile radius. Table 5 (Universities and Engineering Degrees Offered) identifies all 38 universities, the engineering degrees that are offered and at what level (undergraduate and/or graduate). Table 6 (University's Faculty, Student and Budget Information) covers all 38 universities, their faculty information, student information and, if available, their budget information. Table 7 (Number of Engineering Programs Offered by Specialty and Level) is organized by engineering specialty and degree level, not university level. Table 8 identifies the rankings for selected universities and engineering programs and contains the US News and World Report ranking for universities, engineering programs and engineering specialties. Only universities that meet certain criteria are included in this table.

Table 9 lists the top five undergraduate programs by engineering specialty in the nation. It covers eight engineering specialties, but US News and World Report did not identify metallurgical, ceramic or biomaterials engineering programs. Figure 4 (R&D Contract Funding) identifies selected universities and total funding from FY10 contracts from the Air Force, Army, Navy, NASA, DLA and DARPA. Figure 5 depicts the locations of all 38 universities. The figure is color coded to identify the universities within 25 miles of Dayton (green), universities that have engineering programs that are ranked in the Top 5 nationally (red) and then all remaining universities (blue).

Table 1 identifies the companies that met the mileage and material discipline criteria. It contains companies, the distance from Dayton and specific material discipline. A total of 69 companies met the criteria. Of the 69 companies, 33 are located within 25 miles of Dayton and an additional 15 companies are located in the Cincinnati or Columbus area. The other 21 companies are located within 250 miles of Dayton.

To ensure visibility to the materials and manufacturing community, special focus was given to small businesses while researching potential companies for inclusion in this survey.

In some cases, a specific material discipline could not be discerned; in such instances, the company received an "X" in Table 1 that spans the entire materials discipline (ex. Morris Bean & Company). In addition, some companies in Table 1 have no "X" indicator in any material discipline. Those companies were included because it was determined the companies are either (1) prominent in the defense industry with a highly diversified product line and likely have

capabilities in one of these areas, or (2) the company is a small business and the information was not publicly available.

Table 1. Companies and Material Discipline Offered

		Non-Metals				Metals, Ceramics & NDE					Electronics & Optical Materials		
Companies	Distance	1.1 Organic Matrix Composites	1.2 Thermal Management Materials	1.3 Nanomaterials & Nanotechnology	1.4 Biomaterials & Biotechnology	2.1 Titanium Alloy	2.2 Nickel Based Superalloys	2.3 Intermetallics	2.4 Ceramic Matrix Composites	2.5 Nondestructive Inspection (metals & non-metals)	3.1 Silicon and/or Gallium based Electronic and Photodetector Material	3.2 Laser Protection Filters & Devices	3.3 Laser Source Materials (solid state only)
Dayton Area													
Acuren	15									X			
Alek Industries, Inc	8										X		
ATK Military Systems	11												
Azimuth Corporation	10		X	X						X	X	X	
Ball Aerospace & Technologies Corp.	5												
Booz Allen Hamilton	14												
CACI MTL Systems	8												
Clear Creek Applied Technologies, Inc	5												
Computer Sciences Corporation (CSC)	5												
Cornerstone Research Group (CRG)	15			X									
deciBel Research	6											X	
Dynerics, Inc.	2												
Franklin Innovation LLC	21									X			
Infoscitex Corporation	5		X										
M.E.T. Lab	16									X			
Morris Bean & Company	9							X					
Mound Laser & Photonics Ctr	26							X					
National Composite Center	9	X											
Ohio Aerospace Institute	7												
Precision Joining Technologies, Inc	26							X					
Pyramid Tool Inc	15												
Quickstep	9	X											
Renegade	26	X											
Spectral Energies, LLC	7			X								X	
Staub Manufacturing Solutions	16							X					
Techmetals, Inc.	9			X				X					
UES, Inc.	10							X					
Universal Technology Corp.	8	X						X					
University of Dayton Research Institute	9		X					X				X	
Vector Composites	2	X											
Wright Brothers Institute	7												
Wright Materials Production Company	11			X									
Wright State Research Institute	5												
Columbus or Cincinnati Area													
Accutek Testing Laboratory	52									X			
Applied Composites Engineering	68								X				
Ashland Performance Materials	67	X											
Battelle	62												

Table 1. Companies and Material Discipline Offered (Continued)

Companies	Distance	Non-Metals				Metals, Ceramics & NDE					Electronics & Optical Materials		
		1.1 Organic Matrix Composites	1.2 Thermal Management Materials	1.3 Nanomaterials & Nanotechnology	1.4 Biomaterials & Biotechnology	2.1 Titanium Alloy	2.2 Nickel Based Superalloys	2.3 Intermetallics	2.4 Ceramic Matrix Composites	2.5 Nondestructive Inspection (metals & non-metals)	3.1 Silicon and/or Gallium based Electronic and Photodetector Material	3.2 Laser Protection Filters & Devices	3.3 Laser Source Materials (solid state only)
Bodycote Thermal Processing	65									X			
Byron Products	51						X			X			
CFM International (owned by Snecma)	51					X	X						
Cooperheat-MQS Inc	51									X			
Etegent Technologies Ltd	60									X			
GE Aviation	52					X	X						
Gladstone Labs Inc.	67									X			
L-3 Communications Cincinnati Electronics	49												
Maverick	51	X											
Solar Testing Laboratories Inc.	60									X			
Welding Professional Services Ltd.	79									X			
All others within 250 miles of Dayton													
Alcoa Howmet - LaPorte, IN	246						X						
Alcoa Howmet - Whitehall, MI	250*					X							
Applied Composites Engineering	131								X				
ATI-Alleghany Ludlum - Brackenridge, PA	250*						X						
ATI-Alleghany Ludlum - Houston, PA	233					X							
ATI-Alleghany Ludlum - Louisville, OH	204					X							
Aurora Flight Sciences	250*												
Esco Cleveland (a P&W company)	218						X			X			
Fibraplex (also owns Raptor Resin)	250*	X											
GE Aviation KY	250*						X						
Genvac Aerospace	211											X	
Kaiser Optical Systems Inc. (a Rockwell Collins Company)	205			X	X								
Laird (Cleveland, OH)	200		X										
Laird (Schaumburg, IL)	250*		X										
Magnetic Analysis Corp.	127									X			
PCC (Crooksville OH)	120						X						
PCC (Minerva, OH)	205						X						
Raptor Resin (owned by Fibraplex)	250*	X											
RTI International Metals (RMI)	235					X							
Titanium Metals Corp	217					X							
Toho Tenax America	250*	X											

* - These locations are within the 250 mile radius, but slightly over 250 miles according to driving distance.

Table 2 contains sales, employees, certifications and year founded for each of the 69 companies. The sales and employee data came from Thomas Register and the data is limited for most of the companies. Less than half of the companies have data in the sales or employees columns.

Table 2. Company's Sales, Employees, Certifications and Year Founded

Company	Distance	Phone	Sales	Employees	Year Founded	Certification
Accutek Testing Laboratory 3701 Port Union Rd. Fairfield, OH	52	(513) 984-4112			1985	ISO/IEC 17025:2005, NADCAP
Acuren 705 Albany Street Dayton, OH	15	(937) 228-9729	\$10 - 24.9M	50 to 99	1938	NADCAP
Alcoa Howmet 1110 E Lincolnway LaPorte, IN	246	(219) 325-7285			1957 (this location)	
Alcoa Howmet One Misco Drive Whitehall, MI	250	(231) 894-7347				
Alek Industries, Inc 3170 Rodenbeck Dr. Beavercreek, OH	8	(937) 429-2118	\$1 - 4.9M	10 to 49	1984	ISO9001:2008, J-STD-001 Solder
Applied Composites Engineering 705 South Girls School Rd Indianapolis, IN	131	(317) 243-4225	\$1 - 4.9M	10 to 49	1982	
Applied Composites Engineering 4331 East 5th Avenue Columbus, OH	68		\$1 - 4.9M	10 to 49	1982	
Ashland Performance Materials 5200 Blazer Parkway Dublin, OH	67	(614) 790-3333				
ATI – Allegheny Ludlum (Brackenridge, PA) 100 River Road Brackenridge, PA	250	(724) 224-1000	\$4.8B	11,000		ISO-9001, AS-9100, NADCAP, ISO/IEC 17025
ATI – Allegheny Ludlum (Houston, PA) 501 Western Ave Houston, PA	233	(724) 745-2000	\$4.8B	11,000		ISO-9001, AS-9100, NADCAP, ISO/IEC 17025
ATI – Allegheny Ludlum (Louisville, OH) 1500 West Main Street Louisville, OH	204	(330) 875-6200	\$4.8B	11,000		ISO-9001, AS-9100, NADCAP, ISO/IEC 17025
ATK Military Systems 1365 Technology Court Beavercreek, OH	11	(937) 429-9261				
Aurora Flight Sciences 3000 East Benedum Industrial Dr Bridgeport, WV	250	(304) 842-8100				
Azimuth Corporation 4134 Linden Ave, Suite 300 Dayton, OH	10	(937) 256-8571	\$1 - 4.9M	10 to 49	2001	
Ball Aerospace & Technologies Corp. 2875 Presidential Drive Fairborn, OH	5	(937) 429-5005				
Battelle 505 King Ave Columbus, OH	62	(800) 201-2011				

Table 2. Company's Sales, Employees, Certifications and Year Founded (Continued)

Company	Distance	Phone	Sales	Employees	Year Founded	Certification
Bodycote Thermal Processing 710 Burns Street Cincinnati, OH	65	(513) 921-2300	\$1 - 4.9M	10 to 49	1993	ISO 14001, ISO/IEC 17025:2005
Booz Allen Hamilton 1900 Founders Dr # 300 Dayton, OH	14	(937) 256-7262				
Byron Products 3781 Port Union Rd. Fairfield, OH	51	(800) 860-2766		50 to 99	1982	ISO 9002, NADCAP, AS9100B
CACI MTL Systems 3481 Dayton-Xenia Rd. Dayton, OH	8	(937) 426-8301				
CFM International (owned by Snecma) 111 Merchant Street Cincinnati, OH	51	(513) 552-3300			1974	
Clear Creek Applied Technologies, Inc 3000 Presidential Dr, Suite 185 Fairborn, OH	5	(937) 912-5438				
Computer Sciences Corporation (CSC) 3560 Pentagon Park Blvd Beavercreek, OH	5	(937) 320-3244				
Cooperheat-MQS Inc 10540 Chester Rd Cincinnati, OH	51	(513) 771-3292	\$10 - 24.9M	10 to 49		
Cornerstone Research Group (CRG) 2750 Indian Ripple Road Dayton, OH	15	(937) 320-1877				
decibel Research 2661 Commons Blvd, Suite 136 Beavercreek, OH	6	(256) 705-3341				
Dynetics, Inc. 5100 Springfield St, Suite 200, Beavercreek, OH	7	(937) 254-6925			1973	
Esco Cleveland (a P&W company) 34000 Lakeland Blvd. Eastlake, OH	218	(800) 893-7577				AS 9001:B and ISO 9001
Etegent Technologies Ltd 1775 Mentor Ave, Suite 302 Cincinnati, OH	60	(513) 631-0579				
Fibraplex 518 West Lake Ave Celina TN	250	(931) 243-6916				
Franklin Innovation LLC 1521 Lindenhurst Drive Dayton, OH	21	(937) 439-4384				
GE Aviation 1 Neumann Way Evandale, OH	52	(513) 243-2000				
GE Aviation 3050 Nebo Rd Madisonville, KY	250	(270) 825-6213				
Genvac Aerospace 110 Alpha Park Cleveland, OH	211	(440) 646-9986	\$1 - 4.9M	10 to 49		

Table 2. Company's Sales, Employees, Certifications and Year Founded (Continued)

Company	Distance	Phone	Sales	Employees	Year Founded	Certification
Gladstone Labs Inc. 5296 Race Street Cincinnati, OH	67	(513) 921-6700	Under \$1.0M	1 to 9	1960	
Infoscitex Corporation 4027 Colonel Glenn Hwy # 210 Dayton, OH	5	(937) 429-9008			2000	
Kaiser Optical Systems Inc. (a Rockwell Collins Company) 371 Parkland Plaza Ann Arbor, MI	205	(734) 665-8083				
L-3 Communications – Cincinnati Electronics 7500 Innovation Way, Mason, OH	50	(513) 573-6809	\$15.6B	63,000		ISO/IEC 17025:2005, AS9100:2004B, ISO 9001:2008
Laird 4707 Detroit Ave. Cleveland, OH	200	(216) 939-2300				
Laird 1751 Wilkening Ct. Schaumburg, IL	250	(847) 839-6000				
M.E.T. Lab 2681 East River Road Moraine, OH	16	(937) 294-3212			1946	
Magnetic Analysis Corp. 990 Tatmans Rd. Crooksville, OH	127	(740) 342-1990		200 to 499	1928	ISO 9001
Maverick Analysis Corp 11379 Grooms Road Blue Ash, OH	51	(513) 469-9919				
Morris Bean & Company 777 East Hyde Road Yellow Springs, OH	9	(937) 767-7301			1946	ISO 9001:2000
Mound Laser & Photonics Ctr 965 Capstone Dr. Miamisburg, OH	26	(937) 865-4070		30+		ISO 9001:2008
National Composite Center 2000 Composite Dr Kettering, OH	9	(937) 297-9450				
Ohio Aerospace Institute 5100 Springfield St # 308 Beavercreek, OH	7	(937) 424-3483				
PCC 101 China St Crooksville, OH	120	(740) 982-6025				AS9100,ISO9001:2000, NADCAP
PCC 3860 Union Ave. S.E. Minerva, OH	205	(330) 868-6441				AS9100, ISO9001:2000, NADCAP, NDT, ISO17025
Precision Joining Technologies, Inc PO Box 531 Miamisburg, OH	26	(937) 865-4051			1997	
Pyramid Tool Inc 5661 Webster Street Dayton, OH	15	(937) 264-1375	Under \$1.0M	10 to 49		
Quickstep 2000 Composite Dr Kettering, OH	9	(937) 296-5041				

Table 2. Company's Sales, Employees, Certifications and Year Founded (Continued)

Company	Distance	Phone	Sales	Employees	Year Founded	Certification
Raptor Resin 518 West Lake Ave Celina TN	250	(931) 243-6916				
Renegade 3363 South Tech Blvd Springboro, OH	26	(508) 579-7888				
RTI International Metals (RMI) 1000 Warren Ave Niles, OH	235	(330) 544-7633	\$431.0M	1000+	1951	ISO 9001:2000, AS9001A:2001
Solar Testing Laboratories Inc. 3530 Parkway Ln Hilliard, OH	60	(614) 777-6013	\$5 - 9.9M	10 to 49	1969	
Spectral Energies, LLC 5100 Springfield St # 301 Beavercreek, OH	7	(937) 256-7733				
Staub Manufacturing Solutions 3525 Stop 8 Road Dayton, OH	16	(937) 890-4486			1997	ISO 9001:2008
Titanium Metals Corp. (TiMet) 100 Titanium Way Toronto, OH	217	(740) 282-7568	\$857.0M	500 to 999		
Techmetals, Inc. 345 Springfield Street Dayton, OH	9	(937) 253-5311	\$10 - 24.9M	100 to 199	1962	QS 9000, NADCAP, AS9100:2004B, ISO 9001:2008
Toho Tenax America 121 Cardiff Valley Rd. Rockwood, TN	250	(561) 793-0665				
UES, Inc. 4401 Dayton Xenia Road Dayton, OH	10	(937) 426-2808		50 to 99	1973	
Universal Technology Corp. 1270 North Fairfield Road Dayton, OH	8	(937) 426-2808	\$10 - 24.9M	50 to 99	1961	
University of Dayton Research Institute 300 College Park Dr. Dayton, OH	1	(937) 229-2113			1956	
Vector Composites 3251 McCall St Dayton, OH	2	(937) 281-1444				
Welding Professional Services Ltd. 8051 Saybrook Drive Westerville, OH	79	(614) 374-8371	Under \$1.0M	1 to 9	2004	
Wright Brothers Institute 5000 Springfield Street, Suite 100 Dayton, OH	7	(937) 424-8661				
Wright Materials Research Company 1187 Richfield Center Beavercreek, OH	11	(937) 431-8811	\$1-4.9M	1 to 9	1990	
Wright State Research Institute 3640 Colonel Glenn Hwy Fairborn, OH	5	(937) 775-5163				

Table 3 contains the legend for the three maps on the following pages. The first map shows all the companies within 25 miles of Dayton. The second map shows all the companies in the Cincinnati and Columbus area. The third map shows all the rest of the companies within 250 miles. The numbers in Table 3 correspond to the numbers in the maps. Additionally, each company's entry includes a hyperlink to its website.

Table 3. Map Legend

Figure 1: Companies within 25 miles of Dayton		Figure 2: Companies in the Columbus & Cincinnati Area	
1	Acuren	34	Accutest Testing Laboratory
2	Alek Industries, Inc	35	Applied Composites Engineering
3	ATK Military Systems	36	Ashland Performance Materials
4	Azimuth Corporation	37	Battelle
5	Ball Aerospace & Technologies Corp.	38	Bodycote Thermal Processing
6	Booz Allen Hamilton	39	Byron Products
7	CACI MTL Systems	40	CFM International (owned by Snecma)
8	Clear Creek Applied Technologies, Inc	41	Cooperheat-MQS Inc
9	Computer Sciences Corporation (CSC)	42	Etegent Technologies Ltd
10	Cornerstone Research Group (CRG)	43	GE Aviation
11	deciBel Research	44	Gladstone Labs Inc.
12	Dyneris, Inc.	45	L-3 Communications Cincinnati Electronics
13	Franklin Innovation LLC	46	Maverick
14	Infoscitex Corporation	47	Solar Testing Laboratories Inc.
15	M.E.T. Lab	48	Welding Professional Services Ltd.
16	Morris Bean & Company		
17	Mound Laser & Photonics Ctr	Figure 3: Other Companies within 250 miles of Dayton	
18	National Composite Center	49	Alcoa Howmet - LaPorte, IN
19	Ohio Aerospace Institute	50	Alcoa Howmet - Whitehall, MI
20	Precision Joining Technologies, Inc	51	Applied Composites Engineering
21	Pyramid Tool Inc	52	ATI-Allegheny Ludlum (Brackenridge PA)
22	Quickstep	53	ATI-Allegheny Ludlum (Houston, PA)
23	Renegade	54	ATI-Allegheny Ludlum (Louisville, OH)
24	Spectral Energies, LLC	55	Aurora Flight Sciences
25	Staub Manufacturing Solutions	56	Esco Cleveland (a P&W company)
26	Techmetals, Inc.	57	Fibraplex (also owns Raptor Resin)
27	UES, Inc.	58	GE Aviation KY (makes engine blades & vanes)
28	Universal Technology Corp.	59	Genvac Aerospace
29	University of Dayton Research Institute	60	Kaiser Optical Systems Inc. (a Rockwell Collins Company)
30	Vector Composites	61	Laird (Cleveland, OH)
31	Wright Brothers Institute	62	Laird (Schaumburg, IL)
32	Wright Materials Production Company	63	Magnetic Analysis Corp.
33	Wright State Research Institute	64	PCC (Crooksville, OH)
		65	PCC (Minerva, OH)
		66	Raptor Resin (owned by Fibraplex)
		67	RTI International Metals (RMI)
		68	Titanium Metals Corp
		69	Toho Tenax America

Figure 1 depicts the locations of the 33 companies located within 25 miles of Dayton. The red markers indicate the company is providing either research or manufacturing in a non-metal material discipline. The blue markers indicate the company is providing either research or manufacturing in a metal, ceramic or NDE material discipline. The green markers indicate the company is providing either research or manufacturing in the electronics or optical material discipline. The yellow markers indicate the company is providing either research or manufacturing in multiple material disciplines. The brown markers indicate the material discipline was not identified for the company, but there was significant reason to consider this company might provide research or manufacturing in one of the material disciplines.

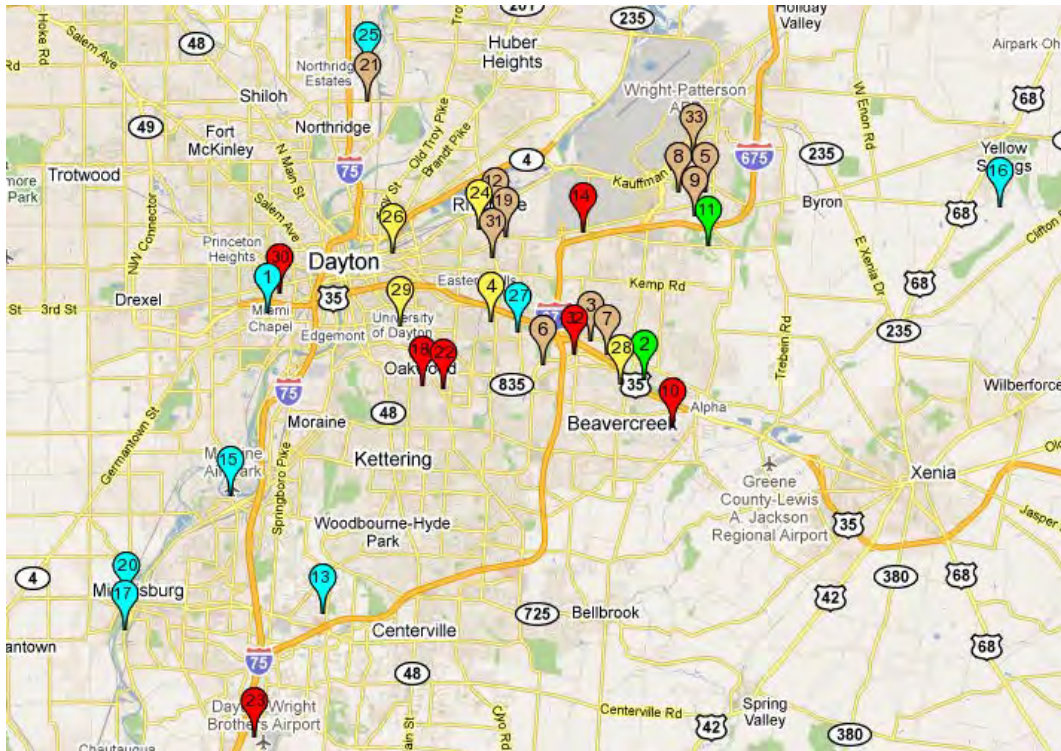


Figure 1. Map of Companies within 25 Miles of Dayton

Figure 2 depicts the locations of the 15 companies located within the Cincinnati and Columbus area. The red markers indicate the company is providing either research or manufacturing in a non-metal material discipline. The blue markers indicate the company is providing either research or manufacturing in a metal, ceramic or NDE material discipline. The green markers indicate the company is providing either research or manufacturing in the electronics or optical material discipline. The brown markers indicate the material discipline was not identified for the company, but there was significant reason to consider this company might provide research or manufacturing in one of the material disciplines.

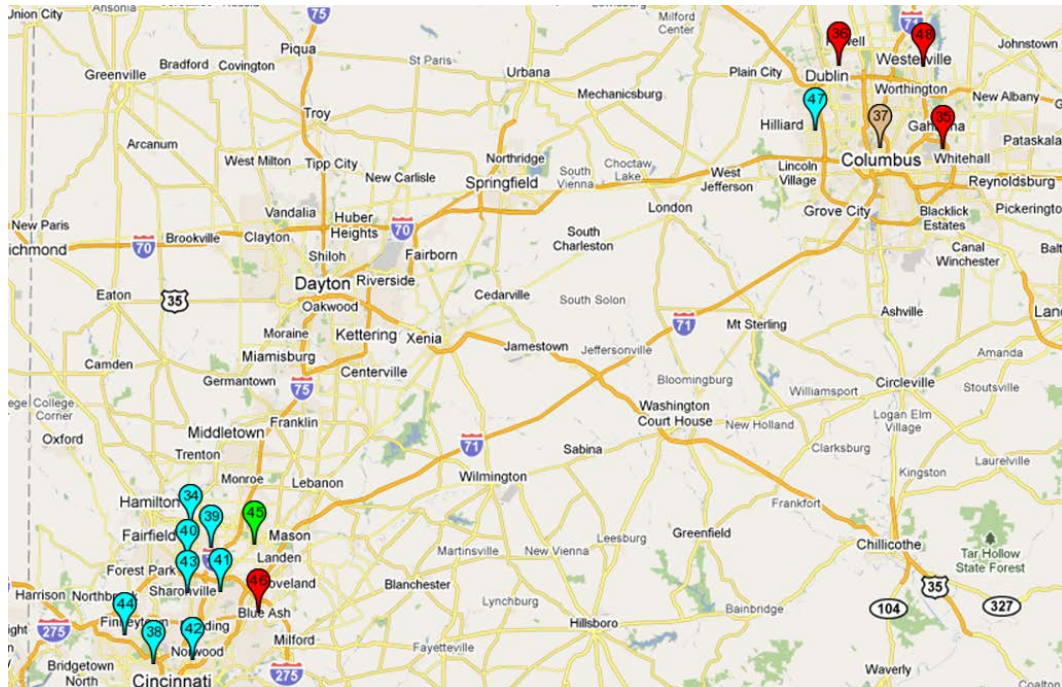


Figure 2. Map of Companies in the Cincinnati and Columbus Area

Figure 3 depicts the locations of the remaining 21 companies located within 250 miles of Dayton. The red markers indicate the company is providing either research or manufacturing in a non-metal material discipline. The blue markers indicate the company is providing either research or manufacturing in a metal, ceramic or NDE material discipline. The green markers indicate the company is providing either research or manufacturing in the electronics or optical material discipline. The brown markers indicate the material discipline was not identified for the company, but there was significant reason to consider this company might provide research or manufacturing in one of the material disciplines.



Figure 3. Map of Companies within 250 Miles of Dayton

Table 4. Legend of Categories

Category	Category Name
1	Non-Metals
1.1	Organic Matrix Composites
1.2	Thermal Management Materials
1.3	Nanomaterials & Nanotechnology
1.4	Biomaterials & Biotechnology
2	Metals, Ceramics, & NDE
2.1	Titanium Alloy
2.2	Nickel Based Superalloys
2.3	Intermetallics
2.4	Ceramic Matrix Composites
2.5	Nondestructive Inspection (metals & non-metals)
3	Electronics & Optical Materials
3.1	Silicon and or Gallium based Electronic and Photodetector Material
3.2	Laser Protection Filters & Devices
3.3	Laser Source Materials (solid state only)

The 250 mile radius covers all or most of Ohio, Indiana, Kentucky and West Virginia, and the southern half of Michigan, eastern Illinois, northern Tennessee, western Virginia and western Pennsylvania. Only universities in this region that offer at least a Bachelor's degree were considered; therefore, community colleges were not considered for this report. Additionally, many universities have satellite campuses located throughout the state. Only the main campus' information was used for this report.

Table 5 identifies those universities that met the mileage and engineering degree criteria. It contains the University, the distance from Dayton and specific degrees offered. Only five universities (Cedarville, Central State, University of Dayton, Wilberforce and Wright State) are located within 25 miles of Dayton and are identified by green in the distance column. The remaining 33 are located within the 250 mile radius. The "Engineering Degrees" fields are populated with U, G or Ds. A "U" in the applicable column represents the university offers an undergraduate degree (Bachelor's) in that field, a "G" represents the university offers a graduate degree (Master's) while "D" represents the university offers a doctoral degree.

Table 5. Universities and Engineering Degrees Offered

		Engineering Degrees							
University	Distance ¹	Metallurgical	Ceramics	Materials	Manufacturing	Chemical	Industrial	Electrical	Biomaterials
Ohio (15)									
Case Western Reserve	215			U/G/D		U/G/D		U/G/D	
Cedarville University	24							U	
Central State University	20				U				
Cleveland State	212				G/D	U/G/D	G/D	U/G/D	Note ²
Miami University	48				U	U/G		U	Note ³
Ohio Northern University	88							U	
Ohio State University	78	Note ⁴	Note ⁴	U/G/D	Note ⁵	U/G/D	Note ⁵	U/G/D	Note ⁴
Ohio University	135					U/G/D	U/G	U/G/D	
University of Akron	197					U/G/D		U/G/D	Note ⁶
University of Cincinnati	52	G/D				U/G/D		U/G/D	
University of Dayton	3			U/G/D		U/G		U/G/D	
University of Toledo	154				U/G/D	U/G/D	U/G/D	U/G/D	
Wilberforce University	21					U	U	U	
Wright State University	9			U/G/D			U/G/D	U/G	
Youngstown State	242			D		U/G	U/G	U/G	
Illinois (2)									
Northwestern University	250			U/G/D		U/G/D	U/G/D	U/G/D	
University of Illinois	237		Note ⁷	U/G/D	Note ⁷	U/G/D	U/G/D	U/G/D	Note ⁷
Indiana (8)									
IPFW	105							U/G	
IUPUI	115							U/G/D	
Notre Dame	250					U/G/D		U/G/D	
Purdue University	106			U/G/D		U/G/D	U/G/D	U/G/D	Note ⁸
Rose-Hulman University	169					U/G		U/G	

Table 5. Universities and Engineering Degrees Offered (Continued)

		Engineering Degrees							
University	Distance ¹	Metallurgical	Ceramics	Materials	Manufacturing	Chemical	Industrial	Electrical	Biomaterials
Indiana (Continued)									
Trine University	179	Note ⁹				<u>U</u>		<u>U</u>	
University of Indianapolis	115							<u>U</u>	
Valparaiso	240							<u>U</u>	
Kentucky (3)									
University of Kentucky	135			<u>U/G/D</u>	<u>G</u>	<u>U/G/D</u>		<u>U/G/D</u>	
University of Louisville	152					<u>U/G/D</u>	<u>U/G/D</u>	<u>U/G/D</u>	
Western Kentucky	250							<u>U</u>	
Michigan (5)									
Kettering University	250				<u>G</u>	<u>U</u>	<u>U</u>	<u>U/G</u>	
Michigan State	250			<u>U/G/D</u>		<u>U/G/D</u>		<u>U/G/D</u>	
University of Detroit Mercy	216				<u>U</u> ¹⁰			<u>U/G/D</u>	
University of Michigan	197			<u>U/G/D</u>	<u>G/D</u> ¹¹	<u>U/G/D</u>	<u>U/G/D</u>	<u>U/G/D</u>	
Wayne State University	213			GD	<u>G</u>	<u>U/G/D</u>	<u>U/G/D</u>	<u>U/G/D</u>	
Pennsylvania (2)									
Carnegie Mellon	250			<u>U/G/D</u>		<u>U/G/D</u>		<u>U/G/D</u>	
University of Pittsburgh	250			<u>U/G/D</u>		<u>U/G/D</u>	<u>U/G/D</u>	<u>U/G/D</u>	
Tennessee (1)									
University of Tennessee	250	Note ¹²		<u>U/G/D</u>		<u>U/G/D</u>	<u>U/G/D</u>	<u>U/G/D</u>	
Virginia (1)									
Virginia Tech	250			<u>U/G/D</u>		<u>U/G/D</u>	<u>U/G/D</u>	<u>U/G/D</u>	
West Virginia (1)									
West Virginia University	250					<u>U/G/D</u>	<u>U/G/D</u>	<u>U/G/D</u>	

Notes

1. Most distances are based on driving distances from Google Maps. Other universities are within a 250 mile radius but exceed 250 miles using driving distance, those universities are identified with a 250 in the distance column.
2. Cleveland State University – They do not offer Biomaterials Engineering degree but do offer biomaterials classes in the Chemical and Biomedical Engineering department.
3. Miami University – They do not offer Biomaterials Engineering degree but do offer biomaterials classes in the Bioengineering department.
4. Ohio State University – They do not offer Metallurgical, Ceramic or Biomaterials Engineering degrees but do offer classes in those specialties as part of the Materials Science and Engineering program.
5. Ohio State University – Manufacturing and Industrial Engineering degrees are part of the Integrated Systems Engineering program.
6. University of Akron – They do not offer a Biomaterials Engineering degree but do offer biomaterials classes in the Biomedical Engineering department.
7. University of Illinois – They do not offer Biomaterials or Ceramic Engineering Degrees. Those fields are part of the Materials Science and Engineering (MatSE) program. Manufacturing Engineering is part of several department offerings.
8. Purdue University – They do not offer a Biomaterials Engineering degree but do offer biomaterial classes as part of the Biomedical Engineering field.
9. Trine University – They offer a Metallurgical minor within the Mechanical Engineering program.
10. University of Detroit Mercy – They do not offer a Graduate-level degree in Manufacturing Engineering but do offer classes as part of the Mechanical Engineering graduate-level program.
11. University of Michigan – The graduate and doctoral programs of Manufacturing Engineering are in the Interdisciplinary Graduate program.
12. University of Tennessee – They do not offer a Metallurgical Engineering degree but students can take metallurgy classes within the Materials Engineering program.

Table 6 contains faculty, student and budget information for each of the 38 universities. Each university reports its faculty statistics different; some only considered full-time faculty while others used both full-time and part-time faculty. In order to standardize the faculty information, the US Department of Education's National Center for Education Statistics website was used. However, this site only gives university faculty numbers, not engineering department faculty. If available, the engineering department faculty levels are derived from the university's website.

All sites don't break down the student numbers by department and the sites that provide the engineering department statistics don't normally break it down by engineering specialty. Therefore, the numbers presented in the engineering column are for the entire department. If available, the student numbers are divided by U (Undergraduate), G (Graduate) and T (Total).

There is limited budget information available in the public domain. Only 14 of the 38 universities publish any budget information and even those that do might not publish it for both the university and their engineering department. Additionally, there are numerous factors that go into budgets and it's difficult to know if universities calculate them the same way. Therefore, comparing one university's budget to another might not be valid.

Table 6. University's Faculty, Student and Budget Information

University	Faculty ¹		Students ²		Budget	
	School	Engineering	School	Engineering	School	Engineering
Ohio						
Case Western Reserve	1,436	111	U-4,227 G-5,610 T-9,837	U-1,068 G-645 T-1,713		84.1M
Cedarville University	305	16	U-3,037 G-65 T-3,102	T-287		
Central State	189	7	U-2,244 G-44 T-2,288	T-76	41.9M	
Cleveland State	1,069		T-16,000	G-354		
Miami University	1,093	44	U-14,872 G-2,395 T-17,267			
Ohio Northern	345	16	U-2,685 G-951 T-3,636	T-396		
Ohio State	4,604	282	U-38,479 G-13,339 T-55,014	U-4,539 G-1,652 T-6,191		
Ohio University	1,195		U-17,117 G-2,718 T-20,397	U-1,325 G-293 T-1,618		
University of Akron	1,751	70	U-24,601 G-4,140 T-29,251	U-2,144 G-356 T-2,500		
University of Cincinnati	3,592	135	U-31,523 G-9,834 T-41,357	G-961		
University of Dayton	1,169	62	U-7,750 G-2,934 T-10,684	U-1,565 G-575 T-2,140		

Table 6. University's Faculty, Student and Budget Information (Continued)

University	Faculty ¹		Students ²		Budget	
	School	Engineering	School	Engineering	School	Engineering
Ohio (Continued)						
University of Toledo	1,679	117	U-20,406 G-2,930 T-23,336	G-356		
Wilberforce	67	6	T-998			
Wright State University	1,218	66	U-13,504 G-4,054 T-17,558	G-581		
Youngstown State	981	61	T-14,682	T-849		
Illinois						
Northwestern	2,613	215	U-8,367 G-8,108 T-16,475	U-1,452 G-1,103 T-2,555	1.531B	
University of Illinois	3,102	404	U-31,173 G-10,322 T-41,495	U-6,970 G-2,711 T-9,681		85.8M
Indiana						
IPFW	807		U-12,876 G-799 T-13,675			
IUPUI	2,500	71	U-22,245 G-8,321 T-30,566	G-141	1.2B	
Purdue University	3,082	442	U-30,836 G-8,890 T-39,726	U-7,012 G-2,680 T-9,692	1.812B	143.9M
Notre Dame	1,085	119	U-8,372 G-3,444 T-11,816	U-817 G-416 T-1,233		
Rose-Hulman Institute of Technology	167		U-1,843 G-120 T-1,963			
Trine University	213	19	T-2,100			
University of Indianapolis	476		U-3,829 G-1,226 T-5,055			
Valparaiso	369	20	U-2,875 G-1,186 T-4,061			
Kentucky						
University of Kentucky	2,165	126	T-28,037	U-2,236 G-515 T-2,751		36.0M
University of Louisville	2,188	91	T-22,031	U-1,467 G-595 T-2,062		29.5M
Western Kentucky	1,175		U-17,645 G-3,067 T-20,712			

Table 6. University's Faculty, Student and Budget Information (Continued)

University	Faculty ¹		Students ²		Budget	
	School	Engineering	School	Engineering	School	Engineering
Michigan						
Kettering University	145		U-2,420 G-330 T-2,750			
Michigan State	2,928	165	U-36,489 G-10,789 T-47,278	U-2,894 G-772 T-3,666	1.02B	26.9M
University of Detroit Mercy	654	13	U-3,065 G-1,362 T-4,427			
University of Michigan	7,003	450	U-26,208 G-15,466 T-41,674	U-5,613 G-2,952 D-8,565	1.553B	151.5M
Wayne State	2,958	140	U-20,765 G-11,021 T-31,786	U-1,102 G-869 T-1,971	898M	15.9M (general fund)
Pennsylvania						
Carnegie Mellon	1,342	228	U-6,020 G-5,510 T-11,530	G-2,334		
University of Pittsburgh	5,718	162	U-18,031 G-10,297 T-28,328	U-2,107 G-898 T-3,005		
Tennessee						
University of Tennessee	2,767	149	U-21,182 G-8,752 T-29,934	U-2,217 G-826 T-3,043	1.904B	70.9M
Virginia						
Virginia Tech	2,412	324	U-23,567 G-7,172 T-30,739	G-2,208	1.1B	
West Virginia						
West Virginia University	2,466	121	U-22,303 G-7,003 T-29,306	G-689	901M	

Notes

1. Faculty consists of Professors, Associate Professors, Assistant Professors and Instructors.

2. Some schools classify Professional Students different from the general student population. Therefore, some of the school's student numbers will not add up correctly.

Table 6, identified the 38 universities and the engineering programs they offer. Electrical engineering is offered by a vast majority of the universities, 97% (37 of 38). Chemical engineering is offered at 73% (28 of 38) of the universities, while industrial engineering and materials engineering is offered at 47% and 39% respectively. A metallurgical engineering degree is offered at only one university, the University of Cincinnati. They offer it at both the Master's and Doctoral level. No universities offer degrees specifically in ceramic or biomaterials engineering. Some schools offer classes in those fields or allow students to specialize in those areas while earning a degree in one of the other engineering fields. Normally those classes are offered within the materials, mechanical or bioengineering programs.

Table 7 identifies the number of engineering degree programs offered by the universities by specialty. The table is broken down by the engineering specialty, the total number of universities that offer that specialty and the level (undergraduate or graduate). For instance, electrical engineering is offered at 37 of the 38 total universities. Thirty seven universities offer electrical engineering at the undergraduate level (Bachelor's), 29 universities offer it at the graduate level (Master's) while 24 offer it at the doctoral level (Doctorate).

Table 7. Number of Engineering Programs Offered by Specialty and Level

Engineering Specialty	Number of Universities That Offer the Engineering Specialty			
	Programs Offered	Undergraduate Level	Graduate Level	Doctoral Level
Electrical Engineering	37	37	29	24
Chemical Engineering	28	28	25	21
Industrial Engineering	18	17	16	14
Materials Engineering	15	14	15	15
Manufacturing Engineering	9	4	6	3
Metallurgical Engineering	1	0	1	1
Ceramic Engineering	0	0	0	0
Biomaterials Engineering	0	0	0	0

US News and World Report conducts yearly surveys to determine the top universities, engineering programs and the top engineering specialties, broken down at the undergraduate and graduate levels. Inputs from the universities, academic deans at the schools, school faculty and professional engineering societies are used to determine school rankings.

Table 8 is broken down using the US News and World Report rankings for the following four categories:

- Best National University (or Best Regional College/University)
- Best Undergraduate Engineering Program
- Best Graduate Engineering Program
- Best Engineering Specialties for both graduate and undergraduate levels.

The Best National University rankings are an over-all school ranking. It takes into account numerous criteria such as academic reputation, retention rates, SAT/ACT scores, acceptance rate and faculty information.

The Best Undergraduate and Graduate programs look only at the university's engineering departments. Most of the schools are ranked in the "Best Programs at Engineering Schools Whose Highest Degree is a Doctorate" group but some are ranked within the "Best Programs at Engineering Schools Whose Highest Degree is a Bachelor's or Master's." Unless otherwise noted, this table assumes the rankings are from the schools offering a doctoral degree.

The Undergraduate and Graduate rankings depict the school's individual engineering specialty ranking. Universities will only be listed if the school has an engineering program listed in the top 5 for undergraduate level or top 10 for graduate level. This section includes all engineering fields, not just the eight requested engineering fields.

One of the following criteria must be met to before the school's ranking would be included in the table: ranked in the top 60 "Best National Universities"; ranked in the top 60 "Best Undergraduate Engineering" programs; ranked in the top 60 "Best Graduate Engineering" programs; ranked in the top 5 "Best Engineering Specialties for Undergraduate" programs; ranked in the top 10 "Best Engineering Specialties for Graduate" programs; ranked in the top 5 "Best Regional Colleges and Universities"

There are excellent universities and engineering programs in Dayton's general vicinity. Eighteen of the 38 universities are rated in the "Best National Universities" or "Best Engineering Programs". Eight of those universities offer engineering degrees that are rated nationally in the top 5 for graduate or undergraduate level programs.

Table 8. Rankings for Selected Universities and Engineering Programs

University	Best National Universities	Best Programs - Undergrad Engineering	Best Programs - Graduate Engineering	Best Engineering Specialty Programs	Undergrad	Grad
Ohio						
Case Western Reserve	41	40	45			
Cedarville University ¹	5					
Miami University ²	79	38				
Ohio Northern ¹	3					
Ohio State	56	26	29			
University of Dayton	99		52			
Illinois						
Northwestern	12	13	20	Industrial Materials Manufacturing	4	4 3 4
University of Illinois	47	6	5	Electrical Materials	3 2	4 2
				Aerospace		7
				Biological	2	1
				Civil	1	2
				Computer	3	4
				Environmental Mechanical	3	3 6
Indiana						
Purdue University	56	8	9	Industrial Manufacturing	3 3	10 10
				Aerospace	4	6
				Biological	3	1
				Civil	5	3
				Mechanical		9
Rose-Hulman ²		1		Chemical Electrical	1 1	
				Civil	1	
				Computer Mechanical	1 1	
Notre Dame	19	45	52			
Valparaiso ²	5	31				

Table 8. Rankings for Selected Universities and Engineering Programs (Continued)

University	Best National Universities	Best Programs - Undergrad Engineering	Best Programs - Graduate Engineering	Best Engineering Specialty Programs	Undergrad	Grad
Michigan						
Kettering ²		21		Mechanical	2	
Michigan State	79	40	52			
University of Michigan	29	7	9	Industrial	2	2
				Electrical	6	7
				Manufacturing	2	2
				Materials	5	
				Aerospace	3	5
				Civil	8	8
				Computer	8	7
				Environmental		6
				Mechanical	5	5
				Nuclear		1
Pennsylvania						
Carnegie Mellon	23	8	6	Computer	2	
University of Pittsburgh	64	56	52			
Virginia						
Virginia Tech		13	24	Industrial		4
				Manufacturing		4
				Biological		7
				Civil		9
				Environmental		7

Notes

1. Best Midwest Regional College
2. Best Engineering program Whose Highest Degree is a Bachelor's or Master's

Table 9 depicts the nation's best undergraduate engineering programs within each specialty. The universities **bolded** are within the 250 mile radius of Dayton. US News and World Report did not rate Metallurgical, Ceramic, or Biomaterials Engineering programs. Other engineering fields were added (Aerospace, Biological, Civil, Computer and Mechanical) that might be of interest. Additionally, this table contains "Best Programs at Engineering Schools Whose Highest Degree is a Doctorate." Rose-Hulman did exceptionally well in the "Best Programs at Engineering Schools Whose Highest Degree is a Bachelor's or Master's." It has the number one ranked program in the Chemical, Civil, Computer, Electrical and Mechanical fields.

Table 9. Top 5 Undergraduate Programs by Engineering Specialty

Engineering Specialty	National Ranking				
	1	2	3	4	5
Aerospace	MIT	Georgia Tech	U of Michigan	Purdue	California Tech
Biological	Texas AM	U of Illinois	Purdue	Iowa State	Cornell
Civil	U of Illinois	U of California Berkley	Georgia Tech	U of Texas	Purdue
Computer	MIT	Carnegie Mellon	Stanford	U of Illinois	U of California Berkley
Electrical	MIT	Stanford	U of Illinois	U of California Berkley	Georgia Tech

Engineering Specialty	National Ranking				
	1	2	3	4	5
Industrial / Manufacturing	Georgia Tech	U of Michigan	Purdue	U of California Berkley	Virginia Tech
Materials	MIT	U of Illinois	U of California Berkley	Northwestern	U of Michigan
Mechanical	MIT	U of California Berkley	Georgia Tech	Stanford	U of Michigan

Note: As rated in the “Best Programs at Engineering Schools Whose Highest Degree is a Doctorate” from US News and World Report.

Figure 4 shows R&D contracts (FY10) for selected schools offering undergraduate and graduate engineering degrees within a radius of 250 miles from Dayton. Data was sourced from Federal Procurement Data System–Next Generation (FPDS-NG), filtered by university, agency (Air Force, Army and Navy), date signed, and product code. Although, DARPA, DLA, and NASA are not part of the DoD, in most cases the data found was significant, and therefore, included in the report.

University of Dayton Research Institute (UDRI) recently was awarded a large contract that was not included in Figure 4. In FY11, UDRI was awarded a \$48.6M contract for R&D in high speed and rapidly reusable aerospace vehicles.

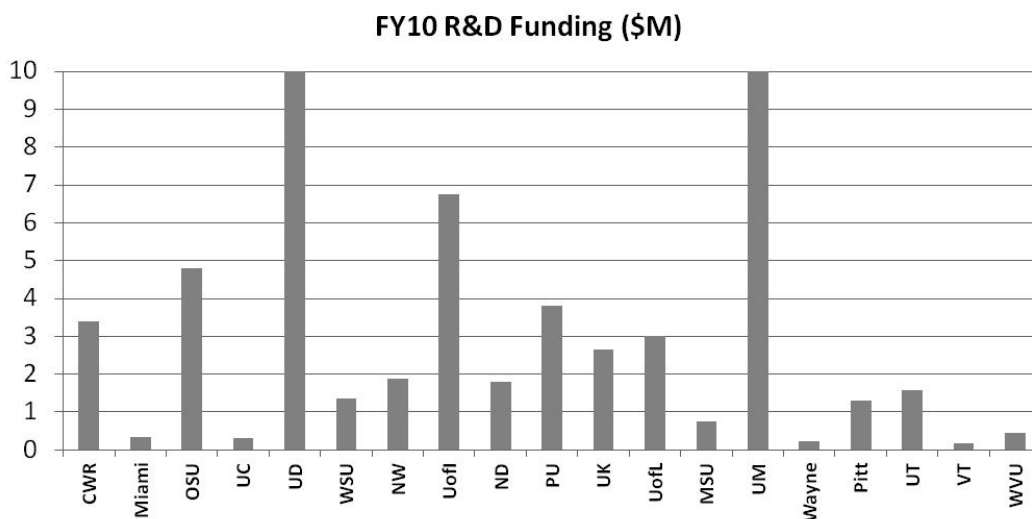


Figure 4. R&D Contract Funding

Figure 5 depicts the locations of the 38 schools offering engineering degrees. The five schools (Cedarville, Central State, Wilberforce, University of Dayton and Wright State) that are located within 25 miles of Dayton are represented with green markers. Eight schools (Northwestern, University of Illinois, Purdue, Rose-Hulman, Kettering University, University of Michigan, Carnegie Mellon and Virginia Tech) are ranked within the “Top 5 Nationally” for at least one of their engineering programs. They are represented with red markers. The remaining 25 schools are represented with blue markers.



Figure 5. University Locations

4.0 SUMMARY

An assessment of the southwestern Ohio region around Dayton OH identified organization supporting the research and development (R&D) of materials and manufacturing techniques. The assessment was bounded by two considerations: a 25 mile radius conducive to a 30 minute drive to attend meetings and a 250 mile radius. The Cincinnati and Columbus regions were also assessed to determine if they offer significant additions to the Dayton OH materials and manufacturing R&D cadre. In addition, an assessment of local colleges and universities offering engineering programs that support materials and manufacturing R&D was conducted using the same two radii constraints.

This Dayton OH region's strength lies within the structural materials area. There are ten organizations supporting organic matrix and ceramic matrix composite R&D. Additionally, there are eight organizations supporting metallic materials R&D in the disciplines of titanium, nickel and intermetallic alloys.

The Dayton OH region is building its R&D capabilities in the new materials science areas of nanotechnology, biotechnology and thermal management materials. There are six organizations involved in nanotechnology and nanomaterials, four in thermal management materials, and two in biomaterials and biotechnology. The applications of nanomaterials and biomaterials are very broad and can apply to structural materials, electro-optical materials, and human performance augmentation materials.

There were nine organizations identified with nondestructive inspection R&D capabilities that would support all aspects of materials and manufacturing.

Only three organizations were identified that are involved in electronic and photodetector materials R&D.

The inclusion of the Cincinnati and Columbus regions did not significantly increase the number of companies involved in materials and manufacturing R&D. Several key contributors such as General Electric and Battelle Memorial Institute would be included by expanding the region.

The assessment of the larger 250 mile radius did not significantly increase the number of companies. The small number of additional companies in this range may be due to limited sources of data. The Dayton Area Defense Contractors Association was used in the local vicinity assessment but no similar local database was used for Cincinnati and Columbus.

There are five major universities within the 25 mile radius offering Materials, Manufacturing, Chemical, Industrial, and Electrical Engineering undergraduate and graduate programs. There are 38 within the 250 mile radius. Of these 38 universities, the University of Dayton leads this larger area in DoD and NASA sponsored R&D.

The 250 mile radius region contains 5 of the top 10 undergraduate and 4 of the top 10 graduate engineering programs. Eleven of the top materials and manufacturing engineering programs in the nation are within this 250 mile range of Dayton OH.

Many universities have combined ceramics and metallurgical engineering into a broader materials engineering curriculum. No regional university offers a biomaterials engineering degree although several offer classes within other degree programs (chemical or materials engineering).